F1-028

CALFED BAY-DELTA PROGRAM
1997 Category III Ecosystem Restoration Projects and Programs Proposal
EXECUTIVE SUMMARY

PROJECT TITLE: An analysis of historical rates of riparian forest habitat regeneration and modeling the current floodplain on the Sacramento River, miles 199 - 219.

PROJECT LEADER: Richard E. Plant, Ph.D.
Department of Agronomy and Range Science
University of California, Davis

PROJECT DESCRIPTION AND PRIMARY BIOLOGICAL/ECOLOGICAL OBJECTIVES:

The conservation of ecosystem processes that regenerate and sustain riparian forests is an important goal for riverine/riparian restoration. This proposal seeks to better quantify the ecological processes that together create, modify, and remove forest structure from the riverine/riparian landscape. As forest structure changes the functions of those forests also change with respect to wildlife species habitat suitability values. The proposed project would supplement and significantly enhance the accuracy and reliability of a project currently underway funded by the U.S. Fish and Wildlife Service (USFWS) through CVPIA funding. Recent findings by this project have identified the need to acquire a more complete historical photographic record of the study area and also to acquire a recent high resolution digital elevation model (DEM) for reliable floodplain inundation mapping of current conditions.

The topographic data available from the U.S. Geological Survey that is suitable for use on this project is too out-of-date (plane table surveyed in 1950) to be used reliably for current floodplain mapping, although it will be used to simulate flooding effects during the 1950s. Many large flow events since 1950 have significantly altered the topography and channel alignment making floodplain mapping for current conditions very unreliable and therefore a more current topographic map is needed. Another benefit to acquisition of a 1997 DEM is it can also allow for modeling alternative floodplain scenarios such as removal of levees or designing setback levees.

The primary ecological objectives are: 1) to document rates of riparian vegetation successional change from an improved temporal record of historic aerial photograph dates; 2) to develop patterns of flood inundation based on historic hydrograph data; 3) to relate patterns of flood inundation to observed vegetation distribution by using a DEM for flood boundary delineation; and 4) to incorporate the successional rate data derived from this study into a geographically explicit ecological model being concurrently developed in the USFWS project (discussed above) to model and estimate regeneration times for various stages of riparian forest growth through natural passive restoration or active enhancement restoration activities. The various vegetation stages will be translated into functional habitat values for vertebrate species sustainability (or viability) through time in and near these forests.

Long-term solutions to restoring greater productivity to ecosystem structure and function will benefit from a more detailed examination of historical riverine/riparian patterns and hydrologic regime patterns. The products from this proposal will contribute to this objective.

APPROACH/ TASKS/ SCHEDULE:

The approach taken by this proposal is to conduct an historical geographic analysis for modeling riparian forest restoration, planning and design strategies. To accomplish this objective the following tasks need to be completed:

1) Acquisition of historic aerial photograph sets;
2) Interpretation and GIS database development of the above historic photographic sets;
3) Acquire a 1997 digital elevation model;
4) Compile the results into report and multimedia formats.

The schedule for this project is a start date of September 1, 1997 and shall be completed by August 31, 1998.

BUDGET COSTS AND THIRD PARTY IMPACTS:

Task 1: Acquire historic aerial photographs	14921
Task 2: Interpret, digitize, and analyze photographs	14386
Task 3: Acquire digital elevation model	35638
Task 4: Summarize findings and a report	5513
TOTAL REQUEST	$70,458

No third party impacts are expected.

APPLICANT QUALIFICATIONS:

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MONITORING AND DATA EVALUATION:

Riparian forest extent and distribution will be studied through time (1938 to 1997) using historical aerial photographs to document the rates of regeneration following disturbances from the hydrologic regime and agricultural clearing. The data will be evaluated through the use of a computer geographical information system and integrated into a potential vegetation model. The data will be displayed and reported in the form of a series of maps and moving maps (animations) to illustrate the dynamics of this system. A manuscript of the findings of this project will be peer reviewed and published in a suitable scientific journal and on the Internet.

LOCAL SUPPORT/ COORDINATION WITH OTHER PROGRAMS/ COMPATIBILITY WITH CALFED OBJECTIVES:

There are several partnerships associated with this project proposal. This project would significantly enhance the effectiveness and accuracy of a research project currently funded by the U.S. Fish and Wildlife Service (USFWS) with CVPIA funding presently underway by the principal investigator of this proposal. Recent research findings found under the USFWS project have identified the needs discussed in this proposal as being critical data sets that would add significant reliability to a model of riparian vegetation succession being developed for vertebrate habitat analysis. This project proposal will also complement the activities of the SB 1086 Riparian Habitat Subcommittee as well as various restoration efforts on the Sacramento River by The Nature Conservancy and other conservation organizations. The digital elevation model will be generated from 1997 color aerial photography (1:12,000) being provided by the California Department of Water Resources. The 1997 DEM data will allow more accurate flood inundation mapping and demonstrate the need for acquiring such data on a valley-wide basis for floodplain planning.

Of the ten stressor categories listed by the SB1086 Riparian Habitat Committee in the CALFED Technical Team Meeting Report (June 1997) the following CALFED objectives are addressed in this proposal:

1. Degraded instream riverine habitat conditions
2. Lack of shaded riverine aquatic (SRA) habitat
3. Lack of floodplain and riparian woodland habitat
4. Erosion/Sediment input/Geomorphic factors

PROPOSAL to CALFED BAY-DELTA PROGRAM

PROJECT TITLE: An analysis of historical rates of riparian forest habitat regeneration and modeling the current floodplain on the Sacramento River, miles 199 - 219.

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RFP PROJECT GROUP TYPE: Services/Research

PROJECT DESCRIPTION

a. Project Description and Approach

The process of regeneration of riparian forests is a critical consideration in the conservation of riverine/riparian ecosystems. Riparian forest patches on the Sacramento River frequently have multiple sources of disturbance (stressors) associated with them resulting in significant changes in habitat structure and function through time. These disturbances can be a combination of both natural and cultural factors acting synergistically on the forest to potentially decrease conservation values by serving to enhance fragmentation of an already highly fragmented forest system. Consequences can be local species extirpations possibly leading to species endangerment problems unless alternative management strategies can be found. On the other hand, an increase in conservation potential might be achieved though various flow regime options to enhance natural hydrographic effects on riverine landforms benefiting riparian forest regeneration. The fluvial processes associated with channel migration are very important to riparian forest development as well as to fish and wildlife.

Changes in forest structure can result from large infrequent flood events that can cause pulses in river channel migration which enhance the processes of bank erosion and point bar deposition. Following these large flood events the shape and topography of the river channel can be altered substantially leading to different vegetation patterns from the scouring effects of erosion and plant colonization from depositional processes and hydrograph drawdown. Since vegetation structure is one of the key variables for modeling vertebrate habitat quality it has been proposed to measure habitat structure in terms of habitat quality for various indicator species or species of special concern. The USFWS is funding a study under the CVPIA to measure these variables, however, it has been determined that the project needs a greater amount of temporal detail beyond the proposed aerial photograph chronosequence interval of 15 years. After extensive agency archival searches for aerial photographic sets within the study area we have located approximately twenty usable sets of low flow (less than 12,000 cfs) photographs and about ten sets of flooding events (greater than 150,000 cfs). We propose that the vegetation dynamics can be better studied and predicted by studying a representative reach in greater temporal detail by increasing the number of observations between photograph dates in the USFWS study that is currently underway.

The primary ecological objectives are to document rates of vegetation successional change to model and therefore estimate regeneration times for various stages of forest growth through passive natural or active enhancement restoration techniques. These various vegetation stages translate into functional habitat attributes for vertebrate species sustainability or viability.

The approach we propose to take is to enhance the existing USFWS study by acquiring two forms of data that are currently difficult to obtain due to cost limitations, but can answer very important ecological questions regarding the regeneration of riparian forests. The first objective is to obtain a more complete photographic record of the study reach. The second objective is to acquire a 1997 digital elevation model (DEM) of the study reach at a sufficient spatial resolution (accurate to 0.5 meters) that can be used with hydrodynamic computer models to accurately depict flood inundation patterns. These flooding boundaries will be defined and then spatially correlated to the vegetation patterns in the historic aerial photograph sets to derive rates of succession. Funds from the USFWS study will be used to purchase the hydrodynamic modeling software to be used with the DEM. The hydrographic record from 1945 to present has been completed in digital form and will be used along with the DEM to quantify the patterns of inundation that have shaped vegetation and habitat distribution through time.

b. Location and/or geographic boundaries of project

The study area is located in southern Tehama County between river miles 199 and 219. This area corresponds to the river reach between Gianella Bridge and Woodsen Bridge, south of Red Bluff. Relative to the map in Attachment A of the CALFED Category III RFP, the study site is located among the Sacramento River Zone, the Colusa Basin and the Butte Basin. The site is mostly contained within two U.S. Geological

Survey quadrangles, Vina and Foster Island, California. The study site is also defined to within two kilometers of the river centerline in 1997.

This section of the river is an alluvial floodplain with several areas of active channel movement which exhibit many of the key signatures of riparian vegetation development. Importantly, this reach is not confined by narrow levees as is the case for much of the river below Chico Landing. The site was chosen because it has the greatest potential to show the dynamics of riparian vegetation succession through time.

c. Expected benefits

The expected benefits derived from this study will be numerous to scientists and managers responsible for managing the Sacramento River's natural resources, such as fish, wildlife and vegetation. In addition, this research will produce several mapping products to: 1) allow the public and resource managers to visualize the complex processes of fluvial dynamics and riparian forest regeneration through time using the photographic record, GIS, and map animation; 2) demonstrate the use of an accurate digital elevation model (DEM) to geographically model floodplain inundation during storm and other high flow events or to model the flooding effects due to the removal of levees (private or public) or changed channel configurations, such as meander cut-offs; and 3) aid in quantifying likely habitat changes that could result in local species extinctions (extirpation). Since the DEM will be created at a resolution higher than currently available elsewhere on the river it could aid in selecting resolutions for future DEM data sets for floodplain modeling and planning.

d. Background and technical information

On March 4, 1997, Steven Greco, Project Participant, gave a presentation to the CALFED Bay-Delta Program Category III Technical Committee titled "Management concepts and opportunities for increasing the ecological potential of riverine/riparian ecosystems on the Sacramento River for fish and wildlife." A brief summary of that presentation can be found in the Sacramento River and Tributaries Technical Team Meeting Report (page 2), however, the following expanded summary of this presentation provides good background information regarding large river ecology and the need to study riparian forest growth. (The references cited in the following background information can be found at the end of the Project Description section of this proposal.)

The Sacramento River between Red Bluff and Colusa is a low-gradient meandering river that hosts a series of salmonid runs each year and has forest remnants distributed along several river reaches that support a wide variety and abundance of wildlife. The historical extent of the riparian forests of the Sacramento River has been reduced dramatically over the past century (Roberts, Howe, and Major 1977; Katibah et al. 1984; Scott and Marquiss 1984). The existing riparian forest in the alluvial floodplain is a dynamic and resilient community adapted to fluvial system cycles of flooding, drawdown, erosion and deposition. The fish and wildlife species of the Sacramento River are also adapted to take advantage of flooding cycles and there is evidence from other large river ecosystems that fish biomass (or yield) is positively correlated with flooding into the floodplain (see Roux and Copp 1996; Bayley and Petrere 1989; Ward and Stanford 1989) as is avian species diversity for riparian forest cover (Hehnke and Stone 1978). Petts and others (1989) examined 81 studies on causes for salmonid population changes in regulated river systems and while they found that 59% of the studies reported declines in fish populations due to negative effects, 18% of the studies reported increased fish populations or no change due to alterations of the hydrologic regime. Through carefully planned and seasonally timed prescription flow releases in combination with natural channel migration processes the life cycles of salmonid fisheries and riparian forest wildlife species could potentially be managed for greater productivity.

River ecosystem ecology is a relatively new field of theory that is being refined and tested with case study research and application. It has emerged from a combination of hydrology, geomorphology, aquatic ecology, limnology, wetland and terrestrial plant ecology. When the river is looked at as a system in the landscape there are evident patterns that suggest an interdependence between upstream reaches and downstream reaches. From this observation an ecosystem theory was proposed in the early 1980's called the

"river continuum concept" or RCC, that proposed rivers are highly directional systems and continuous gradients of energy and nutrients are created from headwaters to estuary (Vannote et al. 1980). This continuum can also be envisioned as a longitudinal cross-sectional view from headwaters to estuary showing a shift from coarse particulate organic matter (CPOM) in the upper reaches to fine particulate organic matter (FPOM) in the lower reaches and the corresponding shift in biological processing from shredders to decomposers to detritivorous organisms. Many of these aquatic insects and microorganisms depend on external input of organic materials such as wood and other litter (known as allochthonous inputs) that are also important food types to many of the life cycle stages of salmonid species who feed upon the aquatic insects (Maser and Sedell 1994).

However, when ecologists tried to apply the RCC to large river systems it did not hold up entirely (Sedell, Richey and Swanson 1989). First, large rivers are often no longer continuous from headwaters to estuary due to dams and other diversion structures that create discontinuities within the fluvial system. In addition the RCC did not consider that the floodplain system behaves much differently than higher order mountain stream systems. Nutrient cycling in the floodplain of large river systems is separated from the main channel for much of the year except when there is overbank flow during flooding events and then nutrients rapidly cycle and intermix with the main channel (Brinson et al. 1983). This mixing can lead to locally high plant productivity and produce many aquatic insects that salmonids feed upon. The diversity of aquatic and terrestrial insect is high in the floodplain and are nutritious for fry and juveniles. The floodplain during overbank flow also provides a great deal of cover for juvenile salmonids among plant species such as willow and grasses that slow water and create eddies that create backwaters.

The dynamics of flood water elevation within the channel and onto the floodplain is known as the "flood pulse concept" proposed by Junk, Bayley and Sparks (1989). The flood pulse concept can be used to evaluate the processes of floodplain productivity of riparian forests and salmonid fisheries. Central to the concept is the aquatic/terrestrial transition zone (ATTZ) which is the interaction area between the aquatic zone flood waters and the terrestrial zone of the floodplain above mean low water and below the 100-year flood event. Floodplain dynamics are characterized by intermittent and recurrent inundation for durations that vary seasonally and by storm events or by dam releases. The relationship between riverine and riparian habitats and how their flooding regimes vary according to cross-section topography relative to the position of the channel is important to understanding their dynamics and managing their productivity.

The Sacramento River has a channel morphology shaped by fluvial processes creating channel beds, channel bars, channel shelves, floodplains, and flood terraces. There are vegetation communities also associated with these topo/hydrographic zones as documented by several ecologists (see Conard et al. 1977, Strahan 1984, and McBride and Strahan 1984). The fluvial processes create a diverse mosaic of vegetation age and size classes providing a diversity of habitat areas. The Sacramento River ecosystem has the following wetland types according to the Cowardin et al. (1979) wetland classification system: 1) riverine, lower perennial; 2) riverine, intermittent; 3) lacustrine, limnetic; 4) lacustrine, littoral; and, 5) palustrine. This classification system, however, does not explicitly include the riparian zone beyond the channel shelf.

The riparian zone influences the quality of fish habitat in many ways. Shade lowers backwater and side channel water temperatures and vegetation litter inputs create microbial populations that spurn invertebrate populations that provide abundant prey for salmonid species. Submerged and partially submerged wood within the channel riparian zone also greatly contributes to aquatic insect diversity (Maser and Sedell 1994). The physical processes of channel migration form important fish habitats and is influenced by riparian vegetation by slowing water velocity and stabilizing banks as well as influencing deposition patterns often causing backwaters to form. The backwaters are valuable salmonid habitats often used as rearing areas. The channel form of a meandering river contains a variety of fish habitats formed through the processes of fluvial geomorphology and in particular the motions of helical flow and bedload transport. The helical flow influences the channel bed form and creates deep pools at the inside of the bends and deposits sediment on point bars. Riffles are formed between the successive bends that provide spawning and feeding areas for adult salmonids. Backwater areas formed from point bar deposition or meander scrolls are often created in flood flows and are influenced by the presence of riparian vegetation.

Fishes need a mosaic and diversity of feeding, refuge and spawning habitat types during their life cycle. Opportunities for movements between these habitats are important to reducing mortality and increasing reproductive success (Schlosser and Angermeier 1995). Studies now being completed on the recent Colorado River prescription flow released from Hoover Dam report that backwater habitats were increased by 20% for spawning fish (Stevens 1997). The flow was 45,000 cfs for a duration of one week.

A better scientific understanding of the processes that shape and form the critical habitats important to fish and wildlife on the Sacramento River is needed to guide a comprehensive ecosystem-scale approach to restoring biotic productivity. A framework to study the complexities of river floodplain ecology should include evaluations of historical data to measure trends through time and geographically explicit ecosystem models to explore alternative ecological successions and productivity strategies. An examination of the physical flooding processes needs to be undertaken to better understand and harness the link between the aquatic and terrestrial systems. Riparian forests should be studied to reveal relationships between floodplain productivity and fish and wildlife productivity by quantifying and modeling habitat quality (see for example Mayer and Laudenslayer 1988 for terrestrial vertebrates in California). Research that provides strategic management information to increase fish and wildlife productivity is greatly needed.

PROJECT PROPOSAL SUMMARY OF USFWS STUDY UNDERWAY:

TITLE: Riparian forest and floodplain ecosystem habitat analysis and modeling on the Sacramento River, miles 200 - 226.

Background

The Central Valley Project Improvement Act (CVPIA) Section 3406 (g) Ecosystem and Water System Operations Models states that there is a need for "improved scientific understanding" and modeling tools that can evaluate the effects of water management operations on riparian ecosystems and fishery productivity. This project proposal addresses four of the nine stated concerns (CVPIA, p. 18):

" • surface-ground and stream-wetland interactions;...
• development and use of base flows and channel maintenance flows to protect and restore natural channel and riparian habitat values;
• implementation of operational regimes at State and Federal facilities to increase springtime flow releases, retain additional floodwaters, and assist in restoring both upriver and downriver riparian habitats;...
• opportunities to protect and restore wetland and upland habitats throughout the Central Valley."

There is a need for effective ecosystem planning tools at appropriate scales to provide managing agencies with the relevant and strategic information for species conservation efforts. This study will produce several useful management tools and products that can be used to delineate potential riparian forest areas and to geographically model potential habitat quality and extent for riparian species.

The goal of this project is to develop a set of hydrological and ecological models as prototypes and apply them to a study reach (river miles 200-226) that can demonstrate how the models could be adapted for general application to the whole Sacramento River alluvial floodplain system below Red Bluff and above the Delta. One objective of the study is to quantify the extent of the floodplain at various recurrence intervals and its influence over the riparian vegetation production. This information would be valuable to a land acquisition and passive restoration reforestation strategy. The vegetation model can also be linked to a habitat quality assessment database such as the California Wildlife Habitat Relationship system (Mayer and Laudenslayer 1988). This would allow resource managers to assess habitat quality conditions and possible options for the conservation of multiple species throughout the ecosystem. Utilization of the flood-pulse concept through manipulation of water facility operation flows by timing water releases with natural seed dispersal events combined with natural meandering channel formations could reestablish cottonwood-willow forest types

through natural processes. Fishery productivity has been shown to increase with floodplain inundation and riparian forest cover (Roux and Copp 1996; Ward and Stanford 1989) as does avian diversity (Hehnke and Stone 1978).

This project has four major components:

1) *Hydrological analysis*

An examination of hydrographic patterns from 1945 to present will be conducted to correlate patterns of riparian forest distribution to flooding regimes. We will develop a prototype digital elevation model (DEM) from USGS mapping information for use with floodplain delineation. From these floodplain maps a spatial model will be developed to identify lowland areas of potential active channel movement and frequent flooding capable of passive reforestation.

2) *Vegetation mapping and analysis*

Aerial photographs from six time periods (including 1997) will be interpreted for vegetation type, cover, and size class. Three principle analyses will be performed on each of these data sets. First, a descriptive analysis will be conducted, and following this a second analysis will develop a set of relationships to the hydrographic regimes (from above). Third, the vegetation data sets will be analyzed to measure the growth rate of riparian forest patches by an examination of size classes between photo time periods. Fieldwork will be conducted to validate the size class, cover class, and growth rates derived from the aerial photos and also to record understory vegetation elements and other habitat elements needed for species-specific modeling.

3) *Potential vegetation model*

A model of potential vegetation will be developed to forecast several possible scenarios for channel migration and flooding regimes over the next century. The building blocks for this model come from the results of the analyses of hydrology and relative elevation and as such will be integrated together to form a predictive model of potential vegetation development. Forecasting will involve running the model with input from meander migration predictions such as in Larsen et al. (in press) where alternative channel configurations were modeled within the study area of this proposal. Alternative ecological successions will be explored using the potential vegetation model.

4) *Potential habitat model*

Since the vegetation data and model will be developed using the classification system of the California Wildlife Habitat Relationship (CWHR) system the ability to geographically model many species of conservation interest is possible. To demonstrate this capability a spatial model will be developed for one riparian obligate avian species to predict habitat suitability index (HSI) values for the 1997 vegetation data set and other historic vegetation data sets to show how habitat quality has changed through time.

Significance of Research

The proposed research project will provide land managers and planners with valuable insights into selecting areas on the Sacramento River with the highest ecological potential to restore various riparian forest habitat types important to salmonid fisheries and many breeding bird species. In the western United States riparian forests support a very high degree of wildlife species diversity along with the associated terrestrial and aquatic insects that enhance trophic level diversity and promote ecological diversity in both the terrestrial and aquatic ecosystems.

The 'flood pulse concept' defines the riparian zone as a seasonally inundated environment with the characteristics of both wetland and terrestrial systems. Within the floodplain this is termed the aquatic/terrestrial transition zone, or ATTZ. During over bank flooding the ATTZ can provide large inputs of nutrients to the main channel (Brinson et al. 1983) and provide expanded cover and feeding habitat for juvenile salmonids (Schlosser and Angermeier 1995) while simultaneously enhancing riparian forest growth beneficial to riparian obligate birds. The link between the aquatic system and the terrestrial system is the riparian zone and the productivity of both systems could be enhanced if the frequency and duration of overbank flooding are managed through regulated flow to promote ecological processes such as vegetation succession while meeting public safety objectives for flood management. The alternating helical flow (or

cork-screw motion) of a meandering channel can form many critical fish habitat types such as pools, riffles and backwaters. The meandering channel fluvial processes of erosion and deposition act together to form both a diversity of fish habitats within the channel and a diversity of terrestrial habitats on the banks and floodplains at various stages of development.

This research examines how these processes operate and will provide management tools to better understand the dynamics of the biota associated with aquatic and riparian ecosystems. Given differing sets of river management options (e.g., flooding regimes, channel configurations, bank protection, levee reconfiguration), a computer geographic information system (GIS) can be a powerful tool for analyzing and developing land conservation strategies for ecosystem-scale planning. The proposed prototype geographic habitat model is being developed to incorporate several variables including: (1) vegetation type, size, and crown closure classes using the California Wildlife Habitat Relationship (CWHR) system to predict the habitat quality, (2) hydrologic flooding events and annual channel migration, and (3) digital elevation modeling.

e. Proposed scope of work

The project involves approximately four major tasks listed in the Buget Table of the Budget Costs section of this proposal. The first task is the acquisition of about thirty sets of historic aerial photographs will be started in September 1998 and completed by October 1997. A summary table will be produced describing each of these data sets. The second major task is interpreting, digitizing, and analyzing the photographs which is to be started by October 1997 and completed by April 1998. The third major task is the acquisition of the digital elevation model (DEM) which will be initiated in September 1997 and to be completed by November 1997. In January an interim report of progress will be submitted. Finally the fourth task is creating a summary of the findings of this project that will be written into report format during May 1998 and completed in June 1998.

f. Monitoring and data evaluation

Riparian forest extent and distribution will be studied through time (1938 to 1997) using historical aerial photographs to document the rates of regeneration following disturbances from the hydrologic regime and agricultural clearing. The data will be evaluated through the use of a computer geographical information system and integrated into a potential vegetation model. The data will be displayed and reported in the form of a series of maps and moving maps (animations) to illustrate the dynamics of this system. A manuscript(s) of the findings of this project will be peer reviewed and published in a suitable scientific journal and animation posted on the Internet for viewing.

g. Implementability

The proposed project combines the use of available historical documents with leading edge engineering computer technology to accomplish the ecological objective of a greater knowledge base for management of the regeneration of riparian forests. The results of this project will be directly implementable through the enhanced capability to forecast the effect of alternative river channel alignments on vegetation and wildlife habitat. A second important consequence of this project is the improved capability to forecast the extent of flood inundation at specified flow rates.

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Scott, L.B., and S.K. Marquiss. 1984. An Historical Overview of the Sacramento River. In: R.E. Warner and K.M. Hendrix (eds.), Californian Riparian Systems, University of California Press, Berkeley, CA, pp. 51-57.

Strahan, J. 1984. Regeneration of riparian forests of the Central Valley. In: R.E. Warner and K.M. Hendrix (eds.), Californian Riparian Systems, University of California Press, Berkeley, CA, pp. 58-67.

Stevens, W.K. 1997. A Dam Open, Grand Canyon Roars Again. New York Times February 25, 1997, pp. B-1, B-12.

Vannote, R.L., G.W. Minshall, K.W. Cummins, J.R. Sedell, and C.E. Cushing 1980. The river continuum concept. Can. J. Fish. Aquat. Sci. 37:130-137.

Ward, J.V., and J.A. Stanford. 1989. Riverine ecosystems: the influence of man on catchment dynamics and fish ecology. In: D.P. Dodge (ed.) Proceedings of the International Large Rivers Symposium. Can. Spec. Publ. Fish. Aquat. Sci. 106, pp. 56-64.

COSTS AND SCHEDULE TO IMPLEMENT PROPOSED PROJECT

a. Budget Costs

Project Task	Direct Labor Months (represents 0.5 FTE for 10 months*)	Direct Salary and Benefits (per month)	Overhead Labor (general Admin and fee)	Service Contracts	Material and Acquistion Contracts	Misc. and Other Direct Costs	Total Cost
*Task 1: Acquire historic aerial photographs	0.5	PGR IV 2652	UC overhead 44.5%	na	Photographic printing: 9000	na	14921
*Task 2: Interpret, digitize, and analyze photographs	3	PGR IV 2652	UC overhead 44.5%	na	na	Supplies: 2000	14386
*Task 3: Acquire digital elevation model	0.25	PGR IV 2652	UC overhead 44.5%	Photogram-metry service: 24000	na	na	35638
*Task 4: Summarize findings in reports	1.25	PGR IV 2652	UC overhead 44.5%	na	na	Supplies and printing: 500	5513
TOTAL							$70,458

(* Source of funding will be from CALFED Bay-Delta Program; additional tasks related to this project will be supplemented with USFWS CVPIA funds at 1.5 FTE for 12 months.)

b. Schedule Milestones

Task 1: The acquisition of the sets of historic aerial photographs will be started in September 1998 and completed by October 1997.
Task 2: Interpreting, digitizing, and analyzing the photographs is to be started by October 1997 and completed by April 1998.
Task 3: The acquisition of the digital elevation model will be iniated in September 1997 and to be completed by November 1997.
Task 4: An interim report will be submitted in February 1998 to report on project progress. A summary of the findings of this project will be written into report format and multimedia format completed by August 31, 1998.

c. Third Party Impacts

No third party impacts are anticipated with this proposed project.

APPLICANT QUALIFICATIONS

The plan of work for the aerial photograph interpretation and GIS mapping with database development will be conducted in Richard Plant's laboratory at the University of California, Davis. This lab is equipped with several PC-based workstations and has access to other computing environments over the campus network. Steven Greco will complete the major tasks 1,2, and 4 listed above with some assistance from a staff research assistant.

The generation of the 1997 digital elevation model (DEM), Task 3, will be contracted to a photogrammetry service capable of producing a DEM to the specifications proposed. The budget cost is derived from an estimate from Advanced Mapping Technologies, Inc., San Carlos, California. This consultant uses the latest methods of softcopy (digital) photogrammetry and has completed projects for many agencies as well as the University of California. Several journal articles have been co-published by this consultant about digital methods of photogrammetry (e.g., see Project Description References list for Myers et al. 1996). Steven Greco will coordinate the DEM work with the consultant.

Project Personnel Biosketches:

Richard E. Plant, Ph.D.
Professor
Departments of Agronomy and Range Science and Biological and Agricultural Engineering
University of California, Davis, California

Richard Plant has over twenty years of experience in the application of modern methods of systems analysis to problems in biology and ecology. He is internationally known for his work in application of these methods to agriculture and resource management, and has lectured on this topic in North America, Asia, Europe, the Middle East, and Australia. He has worked for over fifteen years in the modeling of vegetation dynamics and in the development of decision support systems for crop production and resource management. He has written several invited reviews for special journal issues (e.g. Plant, 1993, 1994, in press) and is the co-author of a well-known book on the subject (Plant and Stone, 1991).

He was one of the first to apply expert system concepts to crop and resource management problems (Plant, 1989a, 1989b) and has developed expert system applications for a wide variety of crops (Plant et al., 1989, Goodell et al., 1990, Real et al., 1994). As a part of this work in expert systems for crop management, he began research into methods for predicting the future dynamics of agroecosystems (Plant et al., 1990, Plant and Loomis, 1991, Plant, 1997). This work led to the development of techniques for forecasting vegetation dynamics in natural ecosystems (Vayssieres et al., 1993, Vayssieres and Plant, in press). Most recently, he has been active in the development of methods for linking state-and-transition models for vegetation dynamics in natural plant communities to geographic information systems to permit geographical analysis and forecasting of these dynamics (Plant et al., submitted).

Selected Publications

Goodell, P.B., R.E. Plant, T.A. Kerby, J. Strand, L.T. Wilson, L. Zelinski, J.A. Young, A. Corbett, R.D. Horrocks, and R. Vargas CALEX/Cotton: an integrated expert system for cotton production and management. California Agriculture 44(5): 18-20. (1990)

Plant, R.E. An integrated expert decision support system for agricultural management. Agricultural Systems 29: 49 - 66 (1989a)

Plant, R.E. A knowledge based method for scheduling crop managment actions. Agricultural Systems 31: 127-135 (1989b)

Plant, R.E. and Loomis, R.S. Model-based reasoning for agricultural expert systems. AI Applications 5: 17-28 (1991)

Plant, R.E. and N.D. Stone. *Knowledge-Based Systems in Agriculture*. McGraw-Hill, New York. (1991)

Plant, R.E. Expert Systems in Agriculture and Resource Management. Technology Forecasting and Social Change 43:241-258 (1993)

Plant, R.E. Agricultural expert systems. 1993 Yearbook of Science and Technology, McGraw-Hill, NY pp. 6-9 (1993)

Plant, R. E. A methodology for qualitative modeling of crop production systems. Agricultural Systems 53:325-348 (1997)

Plant, R.E. Implementation of Cotton Crop Management Expert Systems: Lessons from Ten Years' Experience AI Applications (in press).

Plant, R.E., F. G. Zalom, J.A. Young, and R.N. Rice. An expert system for the diagnosis of peach and nectarine disorders. HortScience.24: 700 (1989)

Plant, R.E., T.A. Kerby, L.T. Wilson, L. Zelinski, and P.B. Goodell. Using knowledge based regression for forecasting in CALEX. AI Applications in Natural Resource Management 4:66-72 (1990)

Plant. R.E., Vayssières, M.P., Greco,, S.E., George, M.R., and Adams, T.E. Linking GIS and State-and-Transition Models of Hardwood Rangeland Vegetation Dynamics. Journal of Range Management (submitted)

Real, J.G., R.E. Plant, J.E. Hill, J.A. Young, L.G. Bernheim, J.F. Williams, S.C. Scardaci, and C.M. Wick. CALEX/Rice: an integrated expert decision support system for rice production in the temperate zone. In Temperate Rice - Achievements and Potential, E. Humphreys, E.A. Murray, W.S. Clampett, and L.G. Lewin, eds., vol. 2, 697-702, (1994)

Vayssieres, M.P., M.F. George, L. Bernheim, J. Young, and R.E. Plant. An intelligent GIS for rangeland impact assessment. Proc. Fourth Annual Conference on Artificial Intelligence, Simulation, and Planning in High Autonomy Systems. pp 109-115 IEEE Press (1993)

Vayssieres, M.P. and R.E. Plant. A qualitative model for hardwood rangeland succession. Applied Landscape Ecology, S.L. Ustin, ed. (in press).

Steven E. Greco, B.S. Landscape Architecture 1987, M.S. Ecology 1993
Ph.D. candidate, Ecology. Currently enrolled, degree expected in June 1998.
Area of emphasis: Ecosystems and Landscape Ecology
Department of Agronomy and Range Science
University of California, Davis, California

SELECTED PROJECT EXPERIENCE

LANDSCAPE ECOLOGIST AND GIS ANALYST, Riparian forest and floodplain ecosystem habitat analysis and modeling on the Sacramento River, miles 200-226. University of California and U.S. Fish and Wildlife Service. The goal of this project is to model the historical hydrodynamics of the Sacramento River for the purpose of creating a set of ecological models as prototypes for application to a study reach (river miles 200-226) that can demonstrate how the models could be adapted for general use on the whole Sacramento River alluvial floodplain system below Red Bluff and above the Delta. An examination of hydrographic patterns from 1945 to present is being conducted to correlate patterns of riparian forest distribution to historical flooding regimes. Digital elevation models (DEM) from USGS mapping information will be developed for use with the hydrodynamic models linked to GIS for floodplain delineation and riparian vegetation modeling. Habitat suitability models will also be developed for avian species. June 1997-present.

GIS ANALYST AND ECOLOGIST, Sierra Nevada Ecosystem Project (SNEP), USDA Forest Service, Pacific Southwest Experiment Station and the University of California, Center for Wildland and Water Resources, Davis, CA. SNEP was a cooperative research project to assess the natural and cultural resources Sierra Nevada mountain range of California and Nevada. I performed research and analyses as a team member of the geographic information system (GIS) laboratory whose charge was to inventory and assemble an extensive ARC/INFO (UNIX OS) database on natural and cultural features and ecological processes in the Sierra Nevada. October 1993 to September 1995.

ECOLOGIST AND GIS ANALYST, Sacramento River Riparian Forest Conservation Project, California Department of Water Resources (DWR), Northern District, Red Bluff, CA, and the University of California, Davis, CA. This project is an on-going interagency effort to collect information regarding the conservation and restoration of riparian forests along the Sacramento River and is a continuation of

the SB 1086 Program. The aim of this research was to identify scientific methodologies to assess current and historic vegetation conditions of the Sacramento River and to develop methodologies for a spatially explicit vegetation model linked to habitat models. April 1995 to May 1997.

GIS SPECIALIST, University of California Natural Reserve System (NRS), Division of Agriculture and Natural Resources, Office of the President, University of California, Oakland, California. Developed a desktop geographic information system (GIS) for the Motte-Rimrock Reserve for research and management of coastal sage scrub habitat of the threatened California gnatcatcher. Other responsibilities included program mission development and computer GIS training of several NRS staff environmental analysts, cartographers and management personnel. July 1992 to July 1993.

GIS AND VEGETATION SPECIALIST, The University Arboretum, University of California, Davis, CA. Developed a desktop GIS for plant collection mapping and management at The University Arboretum. Responsible for field and computer mapping methodologies and database development of fifteen gardens along a mile of the historic north fork of Putah Creek located on the UC Davis campus. Trained and supervised four Arboretum staff employees. October 1991 to August 1992.

GRADUATE ASSISTANT, California Department of Parks and Recreation, Planning Section, Sacramento, CA, in cooperation with the Department of Water Resources (DWR), Northern District, Red Bluff, CA. Geographic analysis of a seven county recreation and public access study of the upper Sacramento River under the SB 1086 Program. Responsibilities include implementing a GIS and design of a database; mapping research and design; data collection and processing; report writing and design; training and supervision of one staff employee. April 1991 to August 1994.

TEACHING EXPERIENCE AND PRESENTATIONS

Presenter CALFED Bay-Delta Program, Category III Committee, Redding, CA. Title: Management concepts and opportunities for increasing the ecological potential of riverine/riparian ecosystems on the Sacramento River for fish and wildlife. March 4, 1997

Poster Presenter, The State of the Sacramento River Conference, sponsored by the Sacramento River Preservation Trust, Red Bluff, CA. Title: Riparian vegetation development: Visualization techniques and linkage to the California Wildlife Habitat Relationship Sysytem. November 9, 1996

Presenter, American Association of Botanical Gardens and Arboreta (AABGA), Pacific Regional Meeting, Woodside, CA. Title: Mapping plant collections and building the database. October 17, 1996

Guest Lecturer, Department of Wildlife, Fish and Conservation Biology, University of California, Davis, CA. Course: Field Methods in Wildlife Ecology (WFB-100); Course instructors: Dr. Dirk Van Vuren and Dr. John Eadie. An introduction to GIS concepts and applications to conservation gap analysis. March 29, 1996.

Instructor, Landscape Architecture Program, Dept. of Environmental Design, University of California, Davis, CA. Course: Landscape Ecology (LDA-183). Co-Instructor: Greg Sutter. An introduction to the concepts and principles of landscape ecology, planning, design, restoration, and GIS as applied to landscape architecture. Course Enrollment: 12 students. Fall 1995.

Presenter, California Riparian Systems Conference, University Extension, University of California, Sacramento, CA. Title: Visualizing Vegetation Change on the Sacramento River. A presentation of a computer morph animation project showing vegetation change between 1952 and 1987 on the middle Sacramento River. November 20, 1995.

SELECTED PUBLICATIONS

Plant, R. E., M. P. Vaysierres, S. E. Greco, M. R. George, and T. E. Adams. (in press). Linking GIS and state-and-transition models of hardwood rangeland vegetation dynamics. Journal of Range Management.

Greco, S. E. 1994. Upper Sacramento River Public Lands Access and Recreation Facilities Inventory: Maps and Database Table. California Resources Agency, Department of Parks and Recreation, State Parks System Planning Section, Interagency Agreement DWR-B-58099, SB 1086 Program (Chapter 885, Statutes 1986), Sacramento, California. 76 p.

Burke, M. T., and S. E. Greco. 1993. Mapping with the Macintosh. The Public Garden 8(4):14-17.

SELECTED GRANTS

1997 U.S. Fish and Wildlife Service, Ecological Services, Sacramento, California. Given for Riparian forest and floodplain ecosystem habitat analysis and modeling on the Sacramento River, miles 200-226. Grant $100,000.

1995 and 1994 Department of Water Resources, Northern District Office, Sacramento River Riparian Habitat Restoration Project. Given for An examination of historic riparian habitat structure and current wildlife habitat relationships on the middle Sacramento River. Grants $15,000 and 10,000.

1992 Jastro-Shields Scholarship Award, College of Agricultural and Environmental Sciences, University of California, Davis. Given for research on the Upper Sacramento River Recreation and Landscape Conservation. Grant Award $2000.

ENDORSEMENTS

Richard E. Plant
Principal Investigator

Steven E. Greco
Project Participant

Richard E. Plant, Acting Chair
Department of Agronomy and Range Science
One Shields Avenue
University of California, Davis, CA, 95616-8515

Sandra M. Dowdy
Contracts and Grants Analyst

Item 8

NONDISCRIMINATION COMPLIANCE STATEMENT

COMPANY NAME: THE REGENTS OF THE UNIVERSITY OF CALIFORNIA

The company named above (hereinafter referred to as "prospective contractor") hereby certifies, unless specifically exempted, compliance with Government Code Section 12990 (a-f) and California Code of Regulations, Title 2, Division 4, Chapter 5 in matters relating to reporting requirements and the development, implementation and maintenance of a Nondiscrimination Program. Prospective contractor agrees not to unlawfully discriminate, harass or allow harassment against any employee or applicant for employment because of sex, race, color, ancestry, religious creed, national origin, disability (including HIV and AIDS), medical condition (cancer), age, marital status, denial of family and medical care leave and denial of pregnancy disability leave.

CERTIFICATION

I, the official named below, hereby swear that I am duly authorized to legally bind the prospective contractor to the above described certification. I am fully aware that this certification, executed on the date and in the county below, is made under penalty of perjury under the laws of the State of California.

OFFICIAL'S NAME: Sandra M. Dowdy
Contracts and Grants Analyst

DATE EXECUTED: JUL 25 1997

EXECUTED IN THE COUNTY OF: Yolo

PROSPECTIVE CONTRACTOR'S SIGNATURE: Sandra M. Dowdy

PROSPECTIVE CONTRACTOR'S TITLE:

PROSPECTIVE CONTRACTOR'S LEGAL BUSINESS NAME: THE REGENTS OF THE UNIVERSITY OF CALIFORNIA

I-000872